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RDTE PROJECT NO. IX141807D174
USAAVCOM PROJECT NO.
USAAVNTA PROJECT NO. 66-06

ENGINEERING FLIGHT TEST OF THE AH-1G HELICOPTER TO DETERMINE THE AREA OF INADEQUATE DIRECTIONAL CONTROL POWER AT 8100 POUNDS GROSS WEIGHT

FINAL REPORT

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PROJECT ENGINEER

GARY C. HALL
MAJOR, TC
US ARMY
PROJECT PILOT

FEBRUARY 1968

US ARMY AVIATION TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

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FOREWORD

During the conduct of this test of the AH-1G helicopter at Grand Prairie Municipal Airport, the helicopter with special instrumentation was maintained by Bell Helicopter Company personnel under contract.

ABSTRACT

This test determined the area of inadequate directional control power of the AH-1G helicopter at 8100 pounds gross weight. The test was conducted at Grand Prairie Municipal Airport near Fort Worth, Texas, from 4 August 1967 to 12 August 1967 by the US Army Aviation Test Activity (USAAVNTA). Paced in-ground-effect (IGE) flight, hovering in winds, approaches to a spot, and arrestment of turn rates at various wind azimuths were investigated. This test proved that the AH-1G Helicopter had inadequate directional control power in winds between 8 and 13.5 knots true airspeed, with a relative wind azimuth between 170-degrees and 250-degrees. These results indicated the need for a "Warning Note" which is proposed in the report, to be included in the operator's manual alerting the operator to effects of wind velocity and direction on the IGE handling qualities. The tail rotor drive train showed evidence of rapid deterioration due to high horsepower operation during mid-test and post-test inspections. The production stability and control augmentation system configuration in the test aircraft was markedly inferior to that previously tested by USAAVNTA. Specifically roll damping was not sufficient to arrest the inherent low frequency (0.6 to 1 cps) roll oscillation of the aircraft. The VHF radio in the test aircraft became inoperative.

INTRODUCTION

BACKGROUND

1. During tests conducted by the US Army Aviation Test Activity (USAAVNTA) on AH-1G helicopter S/N 66-15246 in April 1967 (reference 1, appendix V), it was determined that directional control power was inadequate at some conditions within the contractor-proposed flight envelope. The test was conducted with a 20-degree tail rotor rigging. As a result of these findings the contractor rerigged the tail rotor to 23-degrees in an attempt to solve the directional control power problem. During tests in the 23-degree rigging configuration, the contractor encountered high power loads in the tail rotor drive train when full left directional control inputs were required. The high power loads (290 horsepower) caused considerable damage to the 42-degree and 90-degree gear boxes. Also, the output gear train from the main transmission to the tail rotor drive was damaged. Replacement of all three components was required. Later, in an attempt to solve the problem by use of a reconfigured tail rotor blade, the same phenomenon was experienced with a peak power to the tail rotor of 270 horsepower. This necessitated replacement of the three gear boxes again. The maximum continuous operation design point for the tail rotor power train is 120 horsepower. At this point the contractor determined that the maximum allowable left pedal tail rotor rigging was 19-degrees due to the tail rotor drive train power loading problem. The contractor stated that approximately 230 horsepower was the maximum attainable horsepower with a 19-degree tail rotor rigging. While pursuing a permament solution to this problem on another test helicopter, the contractor was directed to determine the IGE flight envelope at the 19-degree tail rigging with AH-1G helicopter S/N 66-15248 for gross weights of 7500, 8500 and 9500 pounds (reference 2, appendix V). At the completion of this contractor test, USAAVNTA was directed by US Army Aviation Materiel Command (USAAVCOM) to determine the areas of inadequate directional control power for 8100 pounds gross weight with a center of gravity (C.G.) at 194.5 inches.

TEST OBJECTIVES

2. To determine an acceptable IGE flight envelope for the AH-1G helicopter at 8100 pounds gross weight (GW) and a C.G. location of 194.5 inches.

3. To determine the proper wording for a warning note to be included in the operator's manual alerting the operator to effects of wind velocity and direction on the IGE handling qualities of the AH-1G helicopter.

DESCRIPTION

4. The test aircraft was the fourth AH-1G tactical helicopter produced by Bell Helicopter Company designed specifically for the armed role. It is a tandem, two-place, high speed conventional helicopter with a two-bladed door hinge type main rotor and conventional pusher antitorque rotor. The tail rotor rigging was set at 19-degrees because of tail rotor drive train power limitations. A three-axes stability and control augmentation system (SCAS) is used in lieu of the stabilizer bar to improve helicopter stability and handling qualities. The test helicopter is powered by a Lycoming T53L-13 turboshaft engine rated at 1400 shaft horsepower (shp) at sea level (S.L.) standard-day static conditions. The powerplant is derated to 1100 shp at 314 rotor rpm due to maximum torque limits of the helicopter main transmission. The distinctive features of the test helicopter are the 36-inch narrow fuselage, the stub mid-wings with four external stores stations, and the integral chin turret. The flight control system is of the positive mechanical type with conventional helicopter cockpit controls in the pilot's aft cockpit. The copilot/gunner's forward cockpit is provided with sidearm collective and cyclic controls. Control forces are reduced by hydraulic servo cylinders connected to the control system mechanical linkage and powered by dual transmission driven pumps. A synchronized elevator is used to increase controllability and lengthen C.G. range. Force trims connected to the control system mechanical cyclic and directional controls are electrically operated mechanical units used to induce artificial control feel and positive control centering. Ausform armor protection is provided for the crew, engine fuel control and engine compressor sections. Aircraft dimensions and design information are presented in appendix III.

SCOPE OF TEST

5. This test on AH-1G helicopter S/N 66-15248 consisted entirely of directional control power testing during IGE flight, paced flight, hovering IGE over a spot, approaches to a spot and turn rate arrestments at various wind azimuths. This test was conducted at 8010 pounds average GW and 194.5 inch average C.G. location, and without wing stores.

6. Eight flights were conducted during this test at Grand Prairie Municipal Airport near Fort Worth, Texas, for a total of 16 test hours during an elapsed calendar time of 9 days.

7. The flight restrictions which governed these tests were obtained from the contractor and are included in appendix IV.

METHOD OF TEST

8. Paced IGE flight at various wind azimuths was conducted in light, steady winds (0 to 6 Knots (kt), using a calibrated pace car, three wind speed measuring devices, and one wind direction measuring device in the immediate proximity to the test site. Wind speed and direction were continuously monitored and recorded during all testing and correlated with each data point. Control positions, aircraft rates, aircraft attitudes, and tail rotor power were recorded on an oscillograph.

9. Hovering in winds over a spot at various wind azimuths was conducted while wind velocity, wind direction and the control positions required to maintain a heading were recorded.

10. Approaches to a spot at various azimuths were conducted while wind direction, wind velocity and the control positions required to maintain heading were recorded.

11. The capability of arresting a turn rate at various wind azimuths was investigated. Wind direction, wind velocity, and control positions required to arrest the turn rate were recorded.

CHRONOLOGY

12. The chronology of this test program was as follows:

Test helicopter received	4 August 1967
Flight test commenced	4 August 1967
Flight test completed	12 August 1967
Test helicopter returned to contractor	12 August 1967
Draft report submitted	18 August 1967
Final report forwarded	February 1968

RESULTS AND DISCUSSION

PACED FLIGHT

13. Paced flight at selected relative wind azimuths was the primary technique used to produce the quantitative definition of the conditions of inadequate directional control power. Figures 2 through 8, appendix I, show the results of these tests.

14. Flight at critical relative wind azimuths, particularly through the critical airspeed range (approximately 8 to 13 knots true airspeed) KTAS is highly unstable. Rapid and sometimes large directional control excursions are necessary to maintain a heading at these unstable conditions. Pilot recognition threshold and reaction time to small yaw rates and accelerations will determine the frequency and magnitude of the directional control excursions.

15. Figures 2 through 8, appendix I, present both the average directional control position for the condition and the maximum excursion toward full left directional control input for the point. The magnitude of the maximum excursion from the average is an indication of the degree of instability for the condition.

16. Directional control power, for the purposes of this test, was determined to be inadequate where the maximum excursion of directional control extended to less than 12.5 percent of full travel. The left directional control "stop" may vary from 0 to 12.5 percent of full left tail rotor pitch depending upon the position of the SCAS actuator at any instant.

17. Figure 1, appendix I, summarizes the conditions for inadequate directional control power. Between relative wind azimuths of approximately 170-degrees to 250-degrees,there is a range of airspeeds where heading control is difficult or impossible. The airspeeds vary with relative azimuth but generally are between 8 and 13.5 KTAS. At airspeeds above and below this range, no significant directional control problems exist up to an airspeed of at least 30 KTAS. The maximum upper limits of airspeed were not established during this test. All tests were conducted in winds less than 6 kt with a gust spread of approximately 2 kt. Skid height was approximately 4 feet. Rotor speed was maintained at 324 rpm.

18. It must be recognized that the shaded area defined in Figure 1, appendix I, is valid only for the conditions tested. A change in gross weight, density altitude, wind gust spread, skid height, rotor speed, or pilot technique will vary the size of the area of inadequate directional control and its shape.

HOVERING TURNS

19. Hovering over a spot with various wind azimuths was conducted to confirm the results of the paced flight tests. Approximately the same conditions were obtained as in paced flight, by turning the helicopter in heading increments and stabilizing at different relative wind azimuths. The utility of this method is very limited, however, because winds of low gust spread with incremental velocities are not normally available. During the time period of this test, sufficiently uniform winds were available to check the paced flight at two airspeeds, 6 to 8 KTAS and 12.5 to 13 KTAS. The results of these tests are presented in Figures 9 and 10, appendix I. For these limited conditions, good correlation was obtained between the hovering turns and the paced flight.

APPROACHES TO A SPOT

20. Approaches to hover over a spot from various azimuths were conducted while wind velocity, wind direction and the control positions required to maintain heading were recorded. If proper approach techniques are used, the control power problem does not manifest itself until the helicopter is brought to a stabilized hover. Therefore, the actual approach is not significant and the same information may be obtained in a hover. The control power problem may be aggravated by varying approach techniques regarding power application, etc. If the approach is made to touchdown without bringing the helicopter to a hover, the condition of inadequate control power may be avoided. Due to the many variables involved in testing various approach techniques and the questionable validity of any quantitative data collection, it was not considered practical to pursue this test method further.

ARRESTMENT OF TURN RATES

21. The capability of arresting a turn rate at various wind azimuths was investagated. The helicopter was stabilized in an IGE hover into the wind. Then a rapid right pedal displacement was made to induce a turn rate and an attempt was made to stop the

turn on various relative wind azimuths. It is not believed that valid quantitative data can be obtained due to the large number of indefinable variables involved in this test technique such as time and rate of left pedal application.

GEAR BOX WEAR AT STANDARD 19 DEGREE TAIL ROTOR RIGGING

22. On 8 August, after 8.0 hours of flight testing, an inspection of the 42-degree and 90-degree gear boxes was conducted on AH-1G helicopter S/N 66-15248 (reference 3, appendix V). These gear boxes and the main transmission output gear train to the tail rotor drive train were new at the beginning of the test program. During the test, prior to the inspection, the left pedal stop was contacted approximately 34 times for a total of approximately one minute. The 42-degree gear box exhibited considerable scoring and scuffing with high torque wear patterns. The 90-degree gear box exhibited high torque wear patterns, but scuffing was just beginning to take place. The gear boxes would have been rejected in the field but were safe for further controlled testing according to contractor stress engineers. The main transmission output gear train was not inspected at this time. At the completion of the test program all gears were removed and inspected. No noticeable change had occurred on either the 42-degree or 90-degree gear boxes. The spur gears of the main transmission output gear train exhibited only high torque wear patterns. The contractor replaced the entire tail rotor drive train at the completion of the inspection. The deterioration of all gear boxes after a relatively short operating time on the left pedal stop indicates a lessor degree of time till overhaul for those powers attainable at a 19-degree tail rotor rigging and may have serious implications regarding inspection and component replacement interval.

OPERATOR'S MANUAL WARNING NOTE

23. Based on the tests conducted, the following is believed to be the optimum wording for a "warning" note to be included in the operator's flight manual:

WARNING

The AH-1G helicopter, with the tail rotor rigged at 19-degrees blade angle for full left pedal, in accordance with TM 55-1520-221-26, has limited directional control authority which under certain wind and gross weight conditions result in the inability to maintain heading or to maneuver the aircraft. Consequently, operation of the helicopter in a hover, as well as approaches to a hover, in confined areas with the wind in the aft to left quadrant (see figure A) must be avoided.

Use of full left pedal in making hovering turns to the left or in arresting right turn rates should be avoided. The above constraints are necessary to minimize the possibility of damage to the tail rotor drive system.

In the event that conditions of inadequate directional control are inadvertently encountered, control of the aircraft can be regained by allowing the aircraft to rotate clockwise into the wind while maintaining constant rotor speed, collective pitch and engine power.

Under no conditions should the maximum tail rotor pitch setting be adjusted to values greater than 19 degrees, since drive system damage may occur at higher pitch settings.

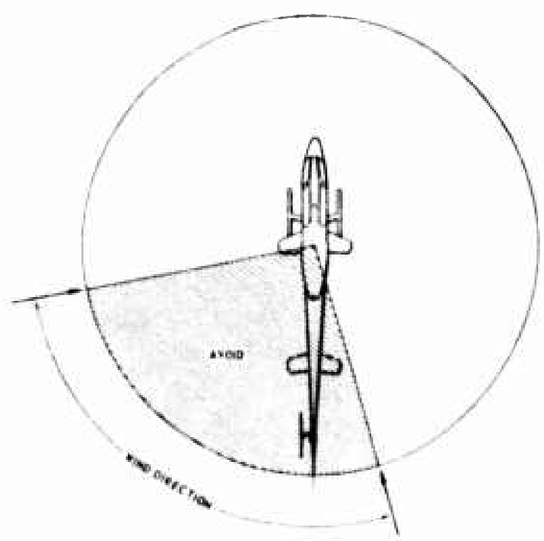


Figure A. WIND DIRECTION

STABILITY AND CONTROL AUGMENTATION SYSTEM (SCAS) PROBLEMS

24. During this test program the helicopter exhibited objectionable handling qualities (reference 4, appendix V). Prior to the first flight, contractor personnel stated that an operable production configuration SCAS card was installed in the test aircraft. On the first flight, it was noted that the roll damping was low, causing the helicopter to exhibit a slightly damped residual roll oscillation.

Oscillograph records were taken of this condition and were reviewed with contractor SCAS engineers. They agreed that the condition was unsatisfactory. The test helicopter was flown by a contractor test pilot who concurred in the comments of the USAAVNTA test team. The production SCAS card was removed and the SCAS card used during the original Army SCAS evaluation conducted by USAAVNTA on 2, 3, and 4 August 1966 was installed. The helicopter was flown by USAAVNTA and contractor test pilots, and all agreed that this was an excellent SCAS configuration. The contractor assured the test team that the necessary changes would be made to the production configuration SCAS to make it satisfactory and that an attempt would be made to incorporate these changes in production AH-1G helicopter number 14 and subsequently to retrofit all earlier aircraft.

VHF RADIO PROBLEM

25. During this test, considerable difficulty was encountered with the VHF radio (reference 5, appendix V). It appears that downwash from the main rotor in a hover causes hot exhaust gases from the engine to be forced into the area where the VHF radio is located and the associated high temperatures render the VHF radio unusable until it has been cooled off in forward flight. The contractor has measured temperatures as high as 160-degrees Fahrenheit in the VHF radio compartment after five minutes of hovering in approximately 100-degree Fahrenheit ambient conditions.

CONCLUSIONS

26. In addition to the IGE flight envelope restrictions found by the contractor's test, this test proved that there were restrictions in the clean configuration, the lightest practical mission gross weight (8010 pounds), for wind velocities greater than 8 kt (para 13 through 18).

27. A "warning" note in the operator's manual is necessary to alert the operator to the effects of wind velocity and direction on the IGE handling qualities of the AH-1G helicopter (para 13 through 18). Refer to paragraph 23 for the "warning" note.

28. Rapid deterioration of the tail rotor drive train gear boxes and main transmission tail rotor drive gear train occurs due to the high power loads induced when the left pedal stop is contacted (para 22).

29. The present production SCAS configuration as presented by the contractor in AH-1G helicopter 66-15248 for Army testing is unsatisfactory due to insufficient roll damping (para 24).

30. The VHF radio installed in the test aircraft was unreliable (para 25).

RECOMMENDATIONS

31. The directional control power of the AH-1G helicopter should be improved to provide an acceptable IGE flight envelope for all mission configurations (para 18 through 21).

32. The "warning" note provided in this report should be included in the AH-1G operator's manual and, in the interim, all AH-1G operators should be notified (para 23).

33. A careful study should be made of the implications of rapid gear box wear with respect to the inspection interval and replacement criteria. The inspection interval and replacement criteria should be modified to insure an adequate margin of safety. Replacement criterion should be relaxed only if based upon documented quantitative data produced by the contractor proving that the present criterion is too conservative (para 22).

34. The appropriate Army agencies should take immediate steps to insure that the contractor has a final optimum SCAS configuration installed in all production AH-1G helicopters and retrofitted to all those not having this configuration. The final configuration should provide handling qualities similiar to those approved by the Army in August 1966 (para 24).

35. The appropriate Army agencies should take immediate steps to insure that the contractor has solved the VHF radio reliability problem (para 25).

APPENDIX I FLIGHT TEST DATA

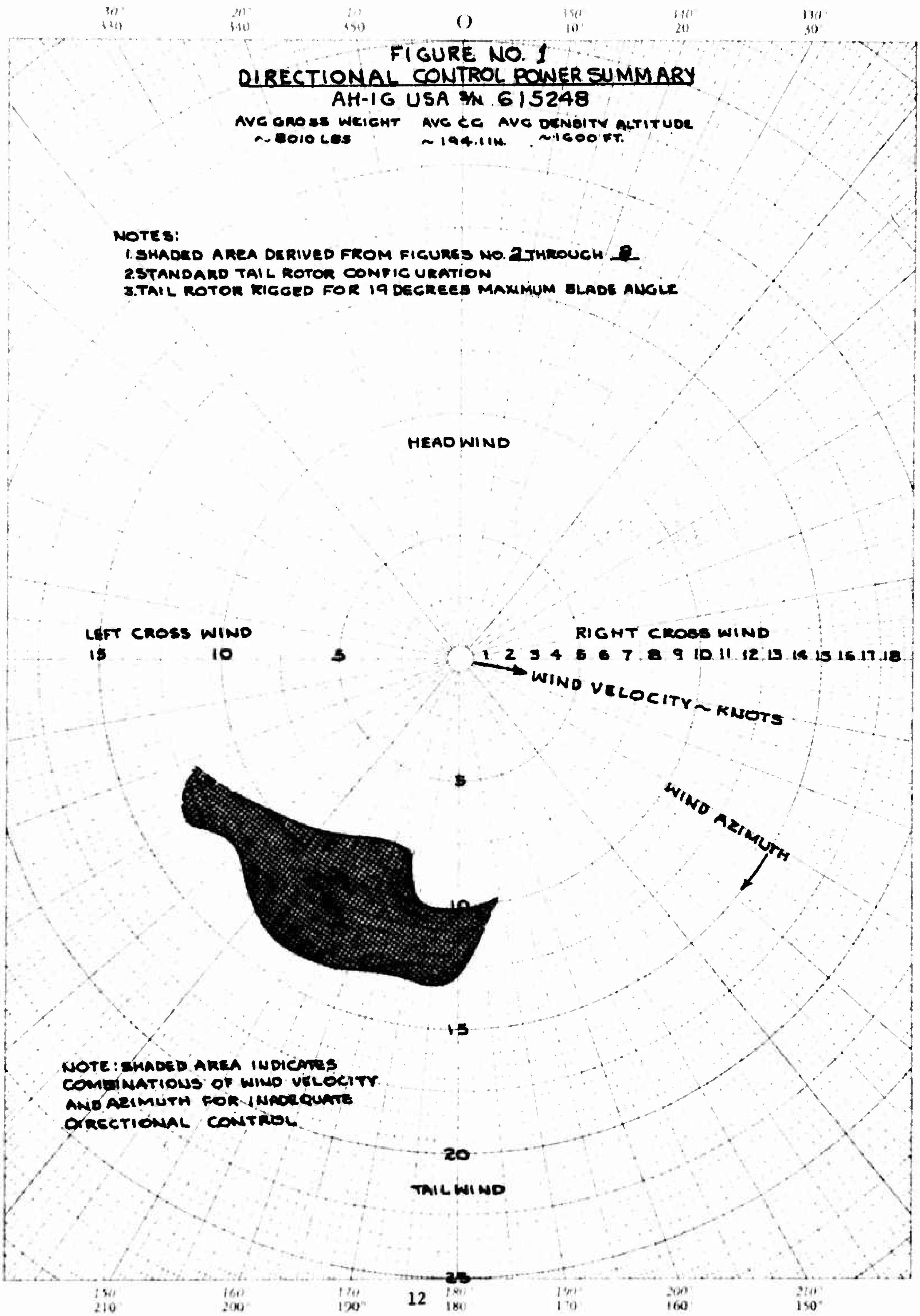


FIGURE NO. 1
DIRECTIONAL CONTROL POWER SUMMARY
AH-1G USA S/N 615248
AVG GROSS WEIGHT ~8010 LBS
AVG CG ~194.1 IN.
AVG DENSITY ALTITUDE ~1600 FT.
NOTES:
1. SHADED AREA DERIVED FROM FIGURES NO. 2 THROUGH 8
2. STANDARD TAIL ROTOR CONFIGURATION
3. TAIL ROTOR RIGGED FOR 19 DEGREES MAXIMUM BLADE ANGLE
HEAD WIND
LEFT CROSS WIND
RIGHT CROSS WIND
WIND VELOCITY ~ KNOTS
WIND AZIMUTH
TAIL WIND
NOTE: SHADED AREA INDICATES COMBINATIONS OF WIND VELOCITY AND AZIMUTH FOR INADEQUATE DIRECTIONAL CONTROL

Figure No. 2

Tail Rotor Pitch Required with Wind Azimuth 90°

AH-1G USA S/N 615248

GROSS WEIGHT ~7880 LBS. C.G. STATION ~194.0 IN. DENSITY ALTITUDE ~2430 FT.

NOTES: 1. STANDARD TAIL ROTOR
2. FULL LEFT PEDAL = 19° TAIL ROTOR PITCH WITH SCAS NULL
3. GROUND SPEED DETERMINED WITH CALIBRATED PACE CAR
4. TRUE AIRSPEED DETERMINED BY VECTOR ADDITION OF GROUND SPEED AND WIND

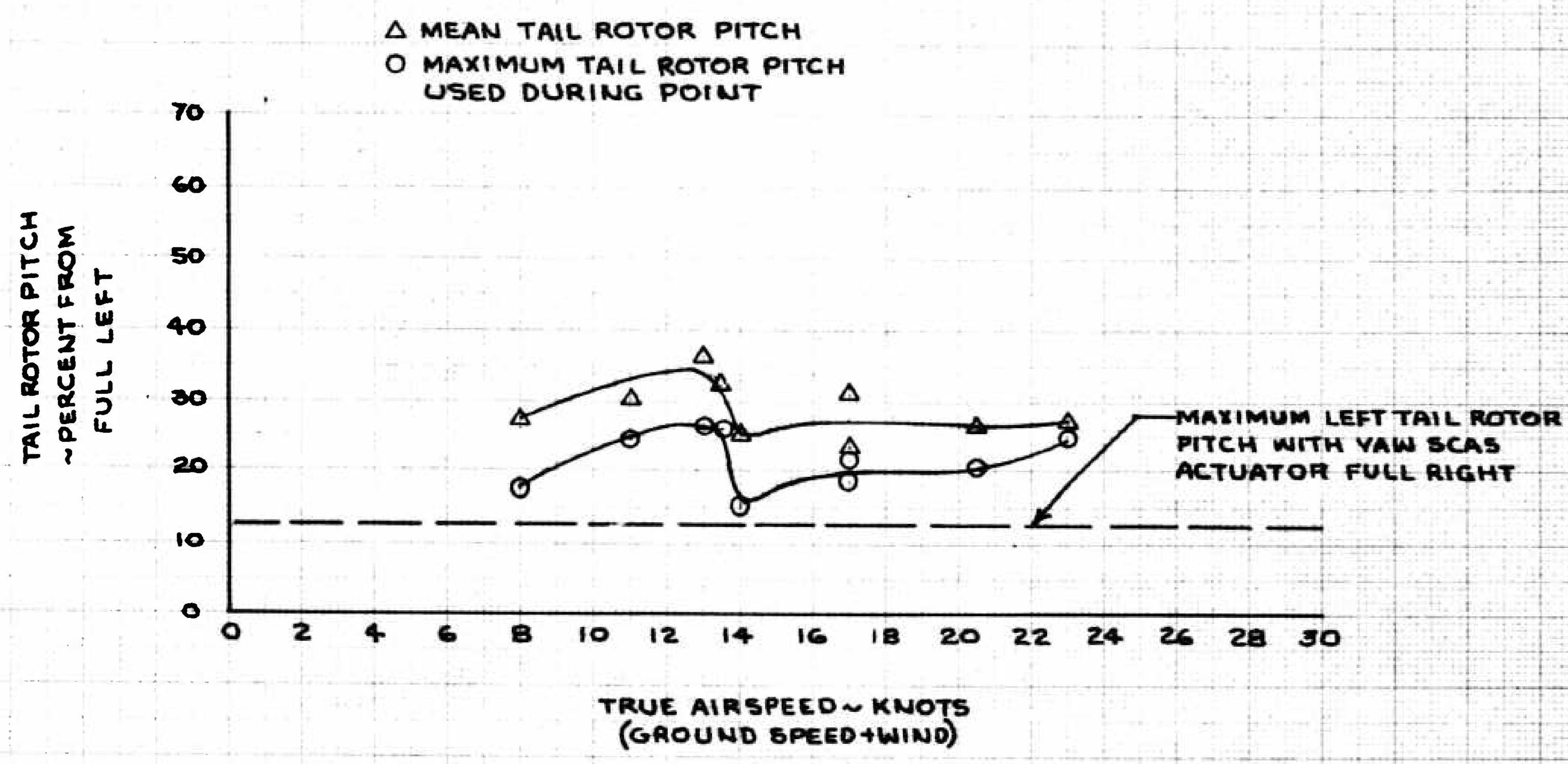


Figure No. 3
Tail Rotor Pitch Required with Wind Azimuth 175°

AH-1G USA S/N 615248

GROSS WEIGHT ~ 7710 LBS. C.G. STATION ~ 193.8 IN. DENSITY ALTITUDE ~ 1900 FT.

NOTES: 1. STANDARD TAIL ROTOR
2. FULL LEFT PEDAL = 19° TAIL ROTOR PITCH WITH SCAS NULL
3. GROUND SPEED DETERMINED WITH CALIBRATED PACE CAR
4. TRUE AIRSPEED DETERMINED BY VECTOR ADDITION OF GROUND SPEED AND WIND.

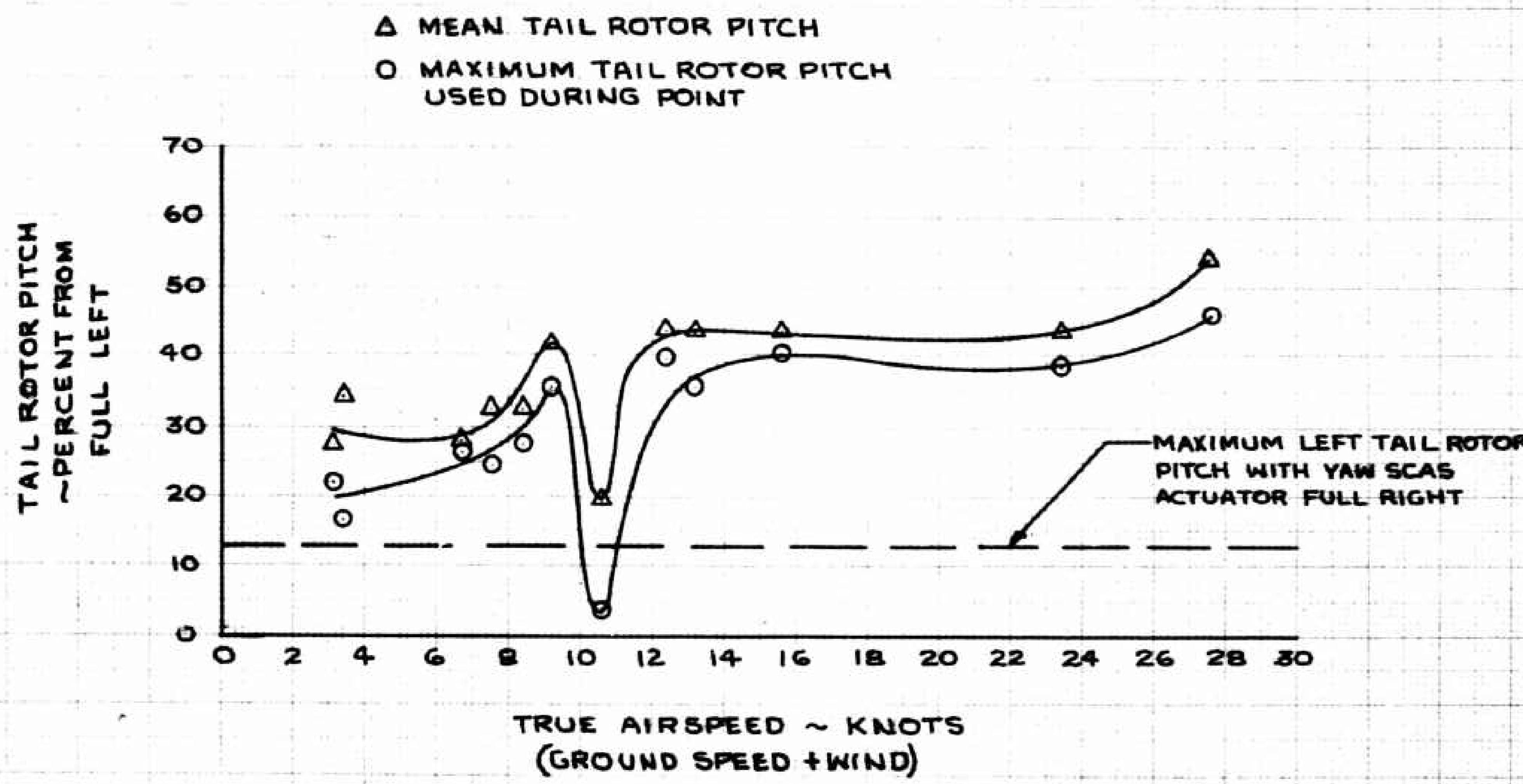


FIGURE NO. 4

TAIL ROTOR PITCH REQUIRED WITH WIND AZIMUTH 190°

AH-1G USA S/N 615248

GROSS WEIGHT ~ 7910 LBS. C.G. STATION ~ 194.0 IN. DENSITY ALTITUDE ~ 1370 FT.

NOTES: 1. STANDARD TAIL ROTOR
2. FULL LEFT PEDAL = 19° TAIL ROTOR PITCH WITH SCAS NULL
3. GROUND SPEED DETERMINED WITH CALIBRATED PACE CAR
4. TRUE AIRSPEED DETERMINED BY VECTOR ADDITION OF GROUND SPEED AND WIND

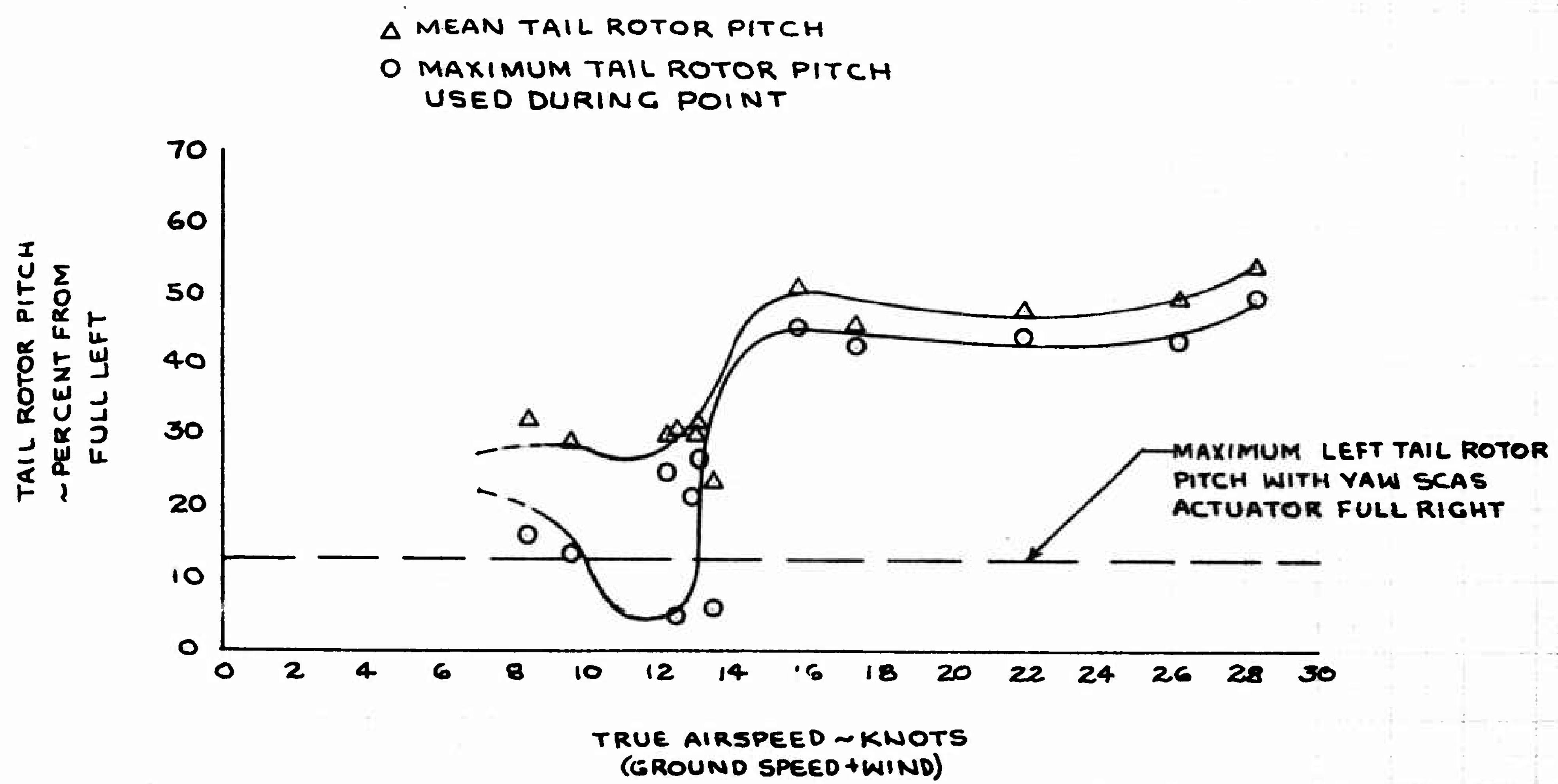


FIGURE NO. 5

TAIL ROTOR PITCH REQUIRED WITH WIND AZIMUTH 195°

AH-1G USA S/N 615248

GROSS WEIGHT ~8270 LBS. C.G. STATION ~194.3 IN. DENSITY ALTITUDE ~1260 FT.

NOTES:
1. STANDARD TAIL ROTOR
2. FULL LEFT PEDAL = 19° TAIL ROTOR PITCH WITH SCAS NULL
3. GROUND SPEED DETERMINED WITH CALIBRATED PACE CAR
4. TRUE AIRSPEED DETERMINED BY VECTOR ADDITION OF GROUND SPEED AND WIND

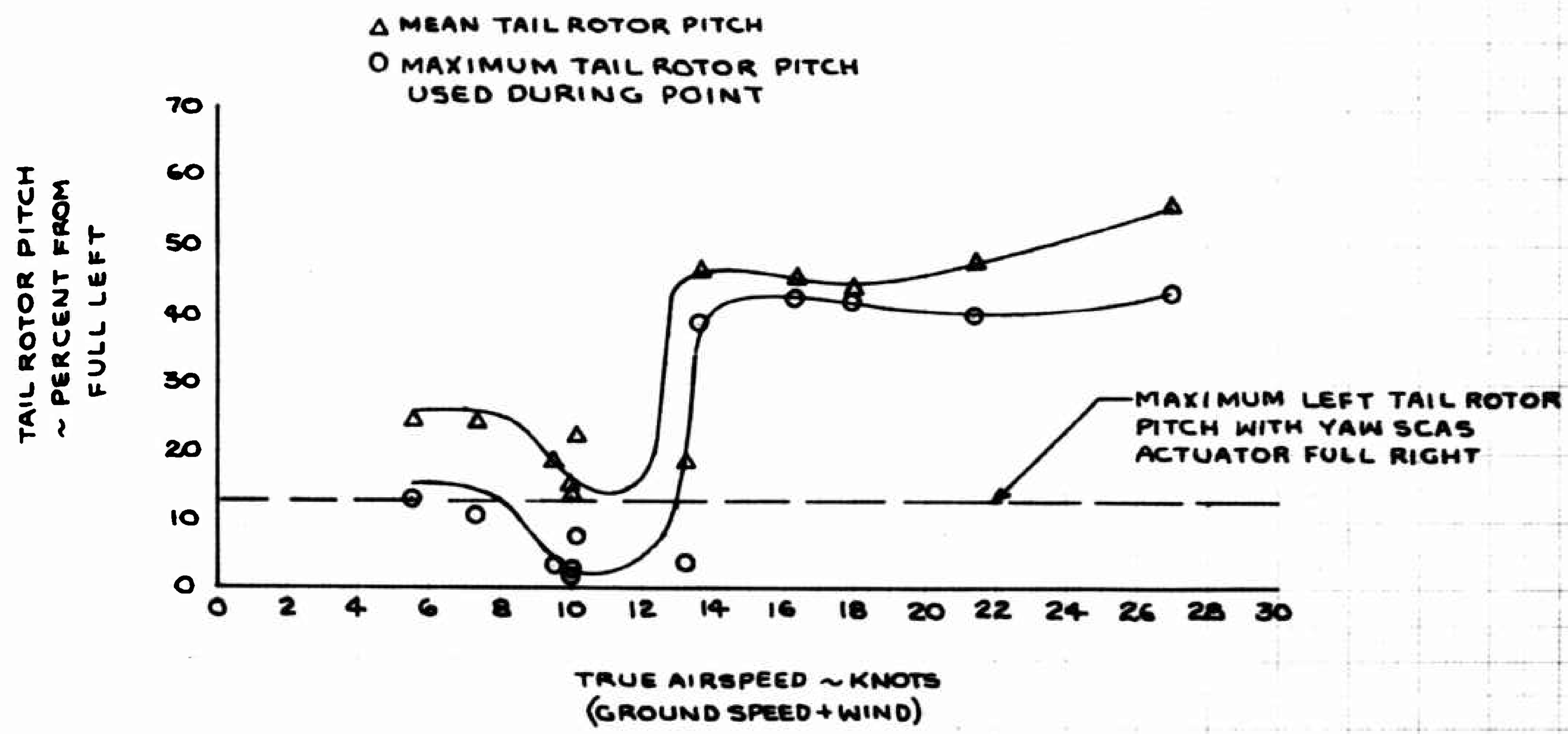


Figure No. 6

Tail Rotor Pitch Required with Wind Azimuth 205°

AH-1G USA S/N 615248

Gross Weight	CG Station	Density Altitude
~8210 LBS.	~194.3 IN.	~1980 FT.

NOTES:
1. STANDARD TAIL ROTOR
2. FULL LEFT PEDAL = 19° TAIL ROTOR PITCH WITH SCAS NULL
3. GROUND SPEED DETERMINED WITH CALIBRATED PACE CAR
4. TRUE AIRSPEED DETERMINED BY VECTOR ADDITION OF GROUND SPEED AND WIND

△ MEAN TAIL ROTOR PITCH

○ MAXIMUM TAIL ROTOR PITCH USED DURING POINT

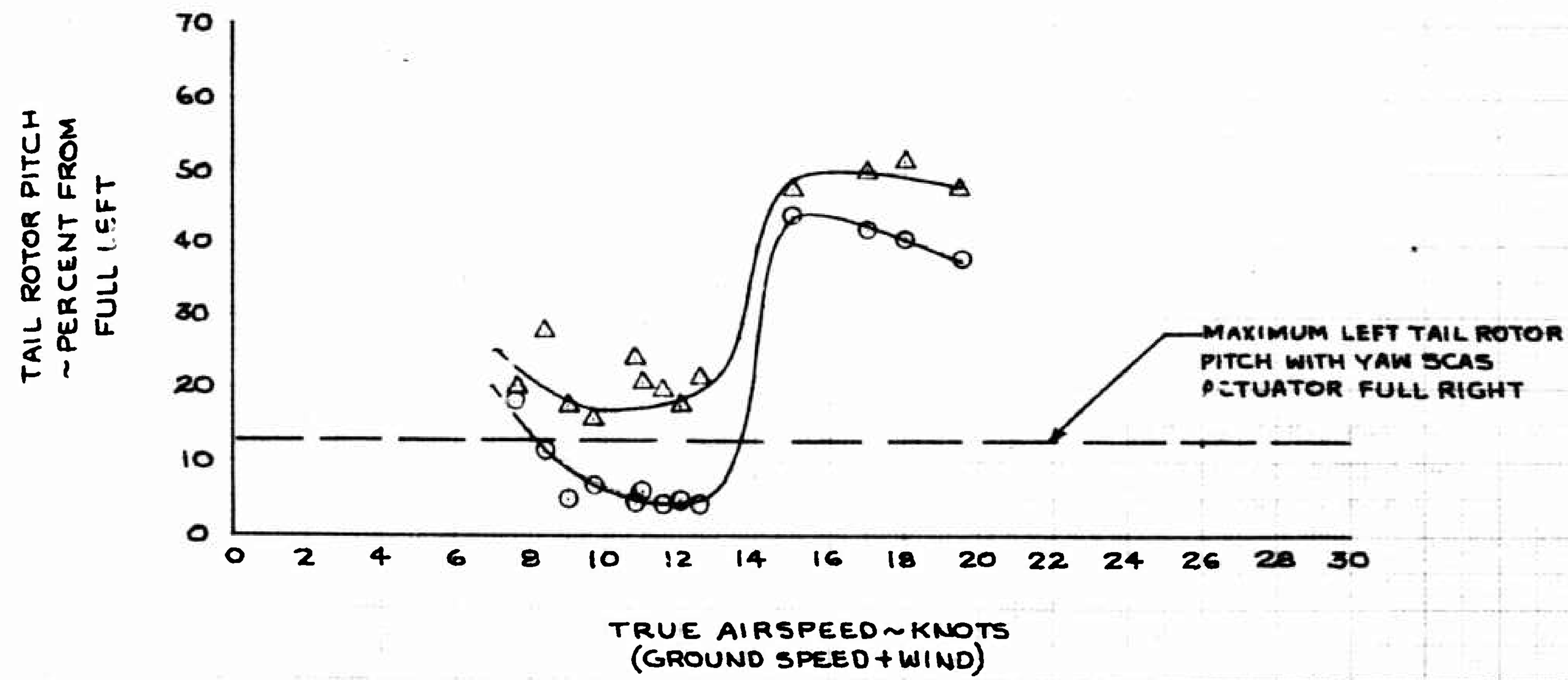


Figure No. 7

Tail Rotor Pitch Required with Wind Azimuth 230°

AH-1G USA S/N G15248

GROSS WEIGHT ~ 7960 LBS

CG STATION ~ 194.1 IN.

DENSITY ALTITUDE ~ 1850 FT.

NOTES: 1. STANDARD TAIL ROTOR

2. FULL LEFT PEDAL = 19° TAIL ROTOR PITCH WITH SCAS NULL

3. GROUND SPEED DETERMINED WITH CALIBRATED PACE CAR

4. TRUE AIRSPEED DETERMINED BY VECTOR ADDITION OF GROUND SPEED AND WIND

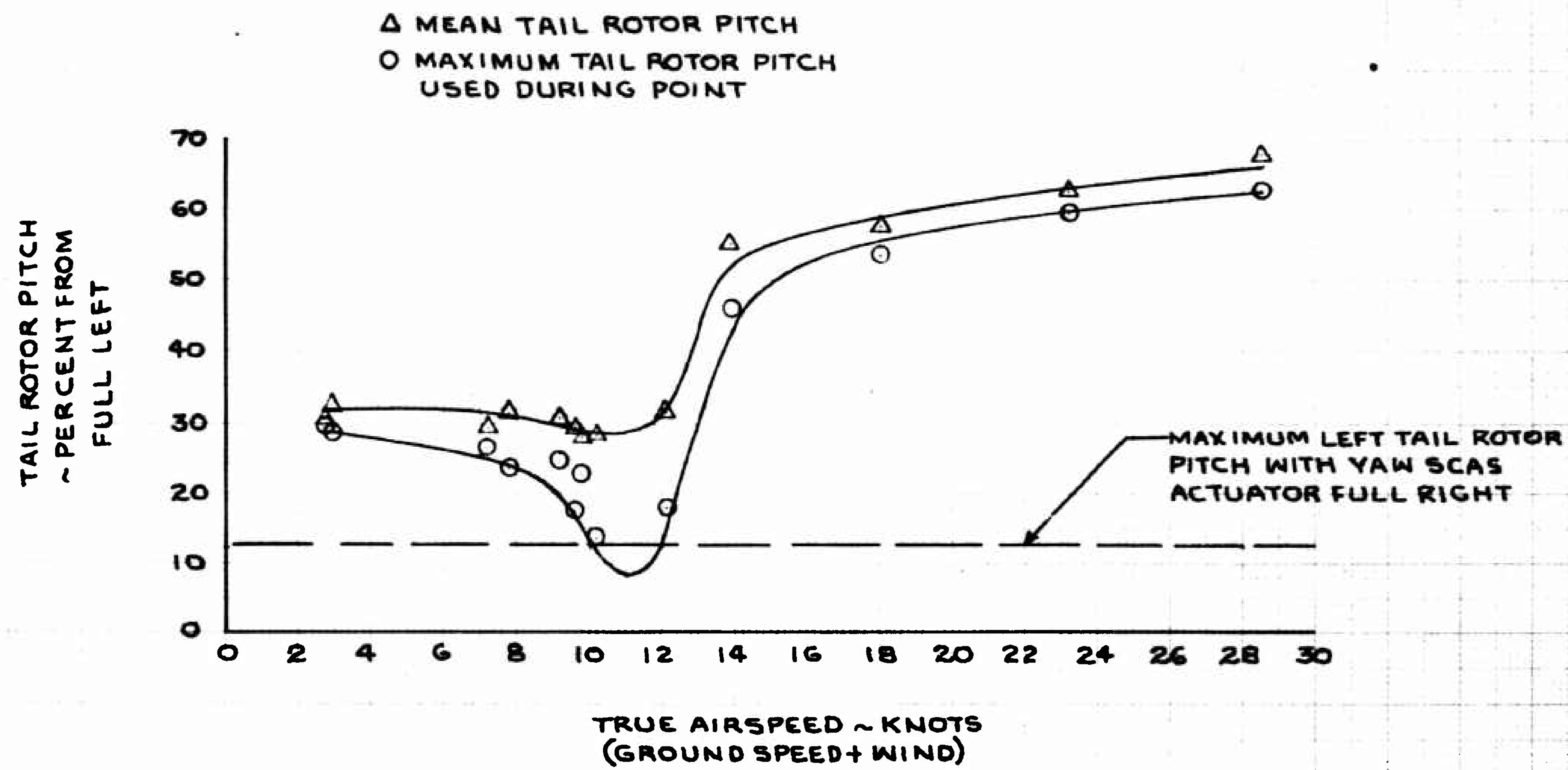


FIGURE NO. 8

TAIL ROTOR PITCH REQUIRED WITH WIND AZIMUTH 240°

AH-1G USA S/N 615248

GROSS WEIGHT ~ 8110 LBS. C.G. STATION ~ 194.1 IN. DENSITY ALTITUDE ~ 1290 FT.

NOTES:
1. STANDARD TAIL ROTOR
2. FULL LEFT PEDAL = 19° TAIL ROTOR PITCH WITH SCAS NULL
3. GROUND SPEED DETERMINED WITH CALIBRATED PACE CAR
4. TRUE AIRSPEED DETERMINED BY VECTOR ADDITION OF GROUND SPEED AND WIND

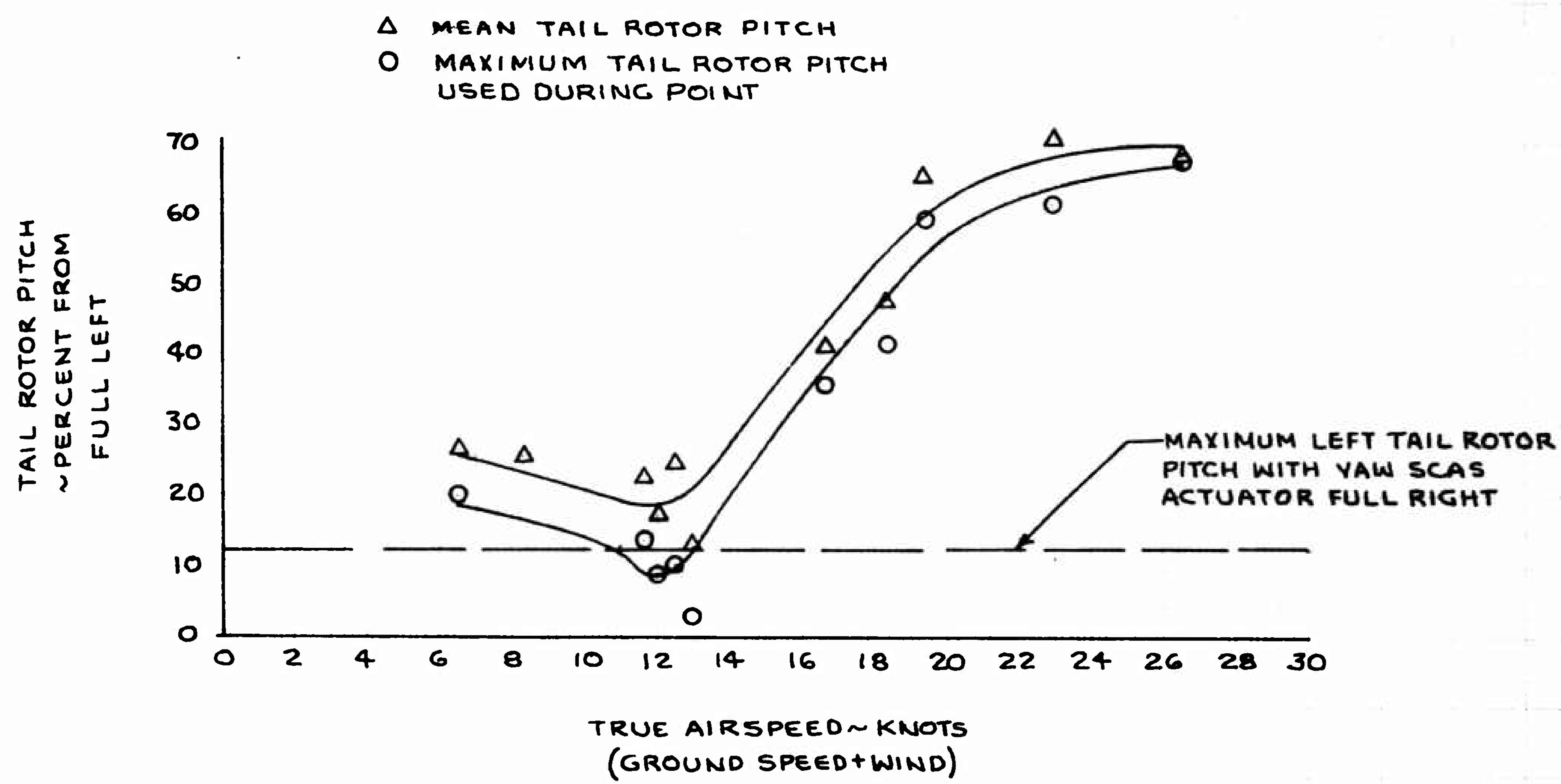


FIGURE NO. 9

HOVERING TURN IN WIND OF 6-8 KNOTS

AH-1G USA S/N 615248

GROSS WEIGHT ~ 8120 LBS C.G. STATION ~ 194.1 DENSITY ALTITUDE ~ 2150 FT.

NOTES: 1. STANDARD TAIL ROTOR
2. FULL LEFT PEDAL • 19° TAIL ROTOR PITCH WITH SCAS NULL

△ MEAN TAIL ROTOR PITCH
O MAXIMUM TAIL ROTOR PITCH USED DURING POINT

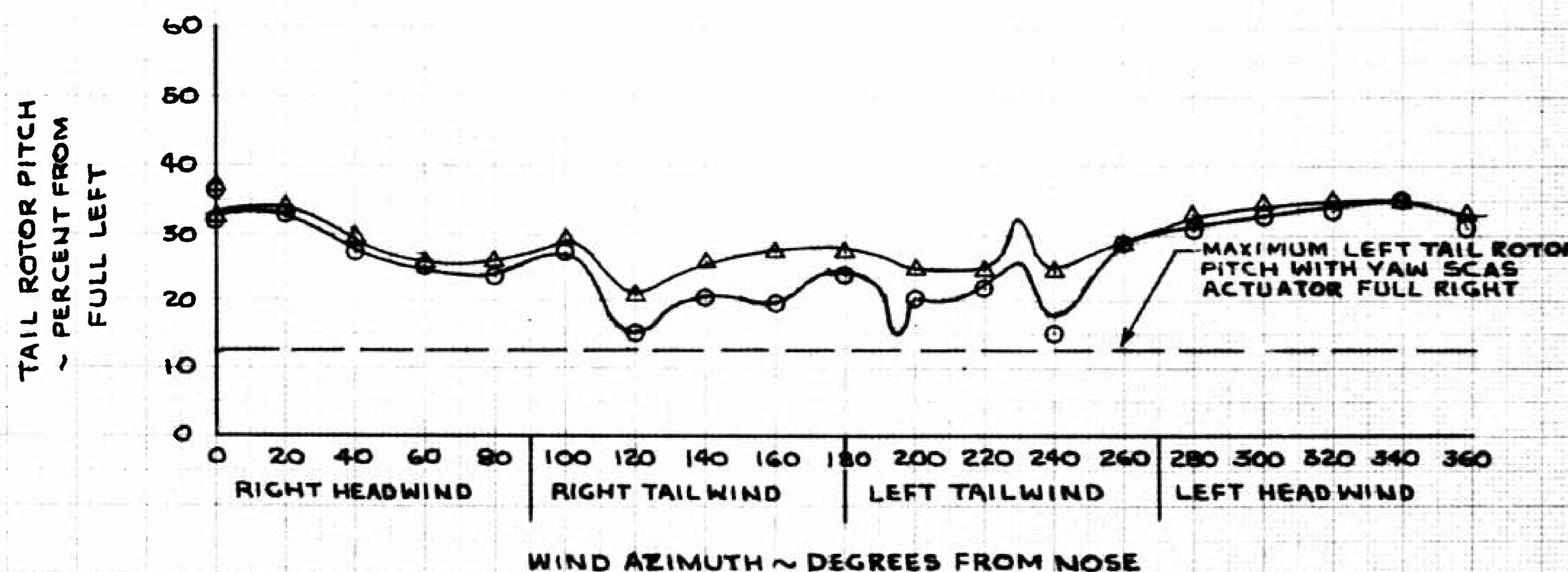


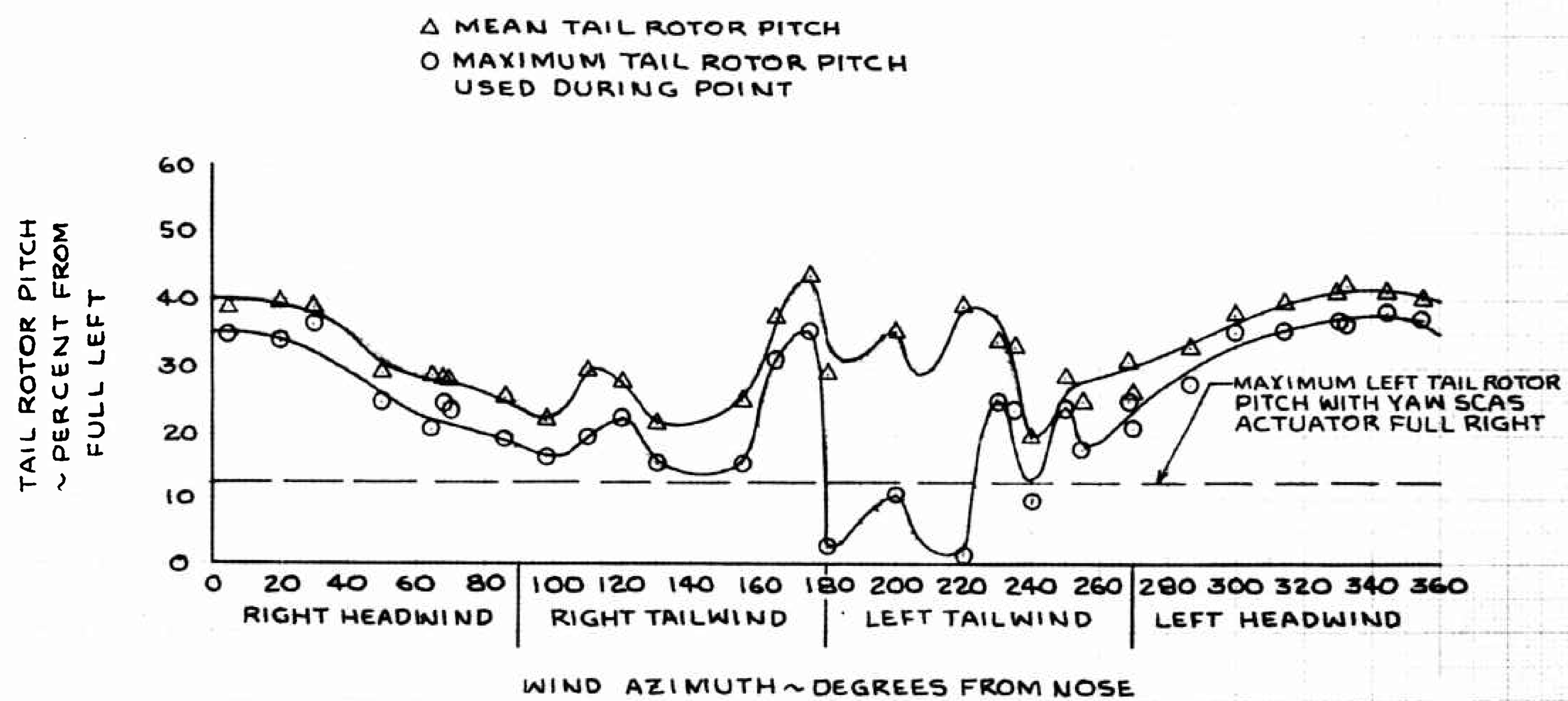
FIGURE NO. 10

HOVERING TURN IN WIND OF 12.5-13 KNOTS

AH-1G USA S/N 615248

GROSS WEIGHT ~8210 LBS. CG STATION ~194.3 IN. DENSITY ALTITUDE ~2240 FT.

NOTES: 1. STANDARD TAIL ROTOR
2. FULL LEFT PEDAL = 19° TAIL ROTOR PITCH WITH SCAS NULL



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APPENDIX II

TEST INSTRUMENTATION

Flight test instrumentation was installed in the test helicopter by the contractor prior to the start of this evaluation. Although other test instrumentation was installed in the test aircraft, only those items on the oscillograph used in data collection for this test are specified below. All instrumentation was calibrated by the contractor and witnessed or approved by the USAAVNTA flight test engineer. The flight test instrumentation was maintained by the contractor throughout the test program. The following parameters were utilized on the oscillograph during this test:

1. Control positions (longitudinal and lateral cyclic, collective, and directional pedals).

2. Linear rotor speed.

3. SCAS actuator positions (longitudinal, lateral and directional).

4. Attitude gyros (pitch, roll, yaw).

5. Angular rate gyros (pitch, roll, yaw).

6. Delta torque.

7. Tail rotor mast torsion.

8. Dorsal fin bending.

9. Tail rotor pitch angle (acme thread).

APPENDIX III

AIRCRAFT DIMENSIONS AND DESIGN INFORMATION

OVERALL DIMENSIONS:

1.	Aircraft length (rotors turning)	52 ft 11.65 in.
2.	Fuselage length	44 ft 5.20 in.
3.	Maximum fuselage width (with stub wings)	10 ft 11.60 in.
4.	Maximum fuselage width (without stub wings)	3 ft 0 in.
5.	Width of skid gear	7 ft 0 in.
6.	Minimum rotor ground clearance (without flexure)	7 ft 10.00 in.

MAIN ROTOR:

1.	Rotor diameter	44 ft 0 in.
2.	Chord	2 ft 3.00 in.
3.	Airfoil Symmetrical special	0009 1/3%
4.	Twist	.455 deg/ft
5.	Disc area	1520.4 ft^2
6.	Blade area	49.5 ft^2 per blade
7.	Solidity ratio	0.651
8.	Preconing angle	2.75 deg
9.	Collective pitch travel	7.29 deg
10.	Longitudinal cyclic travel	$\pm$14 deg
11.	Lateral cyclic travel	$\pm$10 deg

AIRCRAFT WEIGHTS:

1.	Empty weight	5516 lb
2.	Design gross weight	6600 lb
3.	Test gross weight	8010 lb
4.	Maximum gross weight	9500 lb

APPENDIX IV

AH-1G OPERATING LIMITATIONS

1. **Limit Airspeed (V_L):**

   Hog or alternate configuration - 180 KCAS below 3000 feet density altitude. Decrease 8 KCAS per 1000 feet above 3000 feet.

   All other configurations - 190 KCAS below 4000 feet density altitude. Decrease 8 KCAS per 1000 feet above 4000 feet.

2. Gross Weight - Center of Gravity Envelope:

   Forward Limit: Below 7000 lb, Fuselage Station (F.S.) 190. Linear decrease from F.S. 190 at 7000 lb to F.S. 192.1 at 9500 lb.

   Aft Limit: Below 7650 lb, F.S. 201. Linear decrease from F.S. 201 at 7650 lb to F.S. 200 at 9500 lb.

3. Sideslip Limits: 5 degrees at 190 KCAS. Linear increase to 20 degrees at 60 KCAS.

4. RPM Limits (steady state):

   Power on - 6600 to 6400 engine rpm

   324 to 314 rotor rpm

   Power off - 304 to 339 rotor rpm

   transient lower limit 250 rotor rpm

   Power on during dives and maneuvers 319 to 324 rpm

5. Temperature and Pressure Limits:

Engine oil temperature	95°C
Transmission oil tempera' e	110°C
Engine oil pressure	25-100 psi
Transmission oil pressure	30- 70 psi
Fuel pressure	5- 20 psi

6. T53L-13 Engine Limits - Installed:

Normal rated (maximum continuous)	$625^{o}C$
Military rated (30-minute limit)	$645^{o}C$
Starting and acceleration (5-second limit)	$675^{o}C$
Maximum for starting and acceleration	$760^{o}C$
Torque pressure	50 psi

APPENDIX V

REFERENCES

1. Preliminary Letter Report of Phase B Engineering Flight Test of AH-1G Helicopter/Huey Cobra S/N 66-15246, April 1967.

2. Model 209 Controllability, Warning, Approach and Maneuver Envelope Documents presented by Bell Helicopter Company on 28 July 1967.

3. Letter from Cobra Test Team to CO, USAAVNTA, Subject: "Excessive Gear Box Wear at Standard 19 Degree Tail Rotor Rigging on AH-1G Helicopter," 10 August 1967.

4. Letter from Cobra Test Team to CO, USAAVNTA, Subject: "Stability Augmentation System Problems Discovered During Tests of AH-1G Helicopter S/N 66-15248, 4-14 August 1967," 15 August 1967.

5. Letter from Cobra Test Team to CO, USAAVNTA, Subject: "VHF Radio Problem Discovered During Recent Army Testing of the AH-1G Helicopter," 10 August 1967.

APPENDIX VI

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1. ORIGINATING ACTIVITY (Corporate author)
US Army Aviation Test Activity (USAAVNTA)
Edwards Air Force Base, California 93523

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
ENGINEERING FLIGHT TEST OF THE AH-1G HELICOPTER, TO DETERMINE THE AREA OF INADEQUATE DIRECTIONAL CONTROL POWER AT 8100 POUNDS GROSS WEIGHT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final Report - 4 August 1967 through 12 August 1967

5. AUTHOR(S) (First name, middle initial, last name)
Gary C. Hall, Major, TC, US Army, Project Pilot
John R. Melton, Project Engineer

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
January 1968	35	5

8a. CONTRACT OR GRANT NO.

b. PROJECT NO.
USAAVNTA 66-06

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)
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13. ABSTRACT

This test determined the area of inadequate directional control power of the AH-1G helicopter at 8100 pounds gross weight. The test was conducted at Grand Prairie Municipal Airport near Fort Worth, Texas, from 4 August 1967 to 12 August 1967 by the US Army Aviation Test Activity (USAAVNTA). Paced in-ground-effect (IGE) flight, hovering in winds, approaches to a spot, and arrestment of turn rates at various wind azimuths were investigated. This test proved that the AH-1G Helicopter had inadequate directional control power in winds between 8 and 13.5 knots true airspeed, with a relative wind azimuth between 170-degrees and 250-degrees. These results indicated the need for a "Warning Note" which is proposed in the report, to be included in the operator's manual alerting the operator to effects of wind velocity and direction on the IGE handling qualities. The tail rotor drive train showed evidence of rapid deterioration due to high horsepower operation during mid-test and post-test inspections. The production stability and control augmentation system configuration in the test aircraft was markedly inferior to that previously tested by USAAVNTA. Specifically roll damping was not sufficient to arrest the inherent low frequency (0.6 to 1 cps) roll oscillation of the aircraft. The VHF radio in the test aircraft became inoperative.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
AH-1G Helicopter						
8100 Pounds Gross Weight						
Inadequate Direction Control Power						
Warning Note						
Tail Rotor Drive Train						
Stability and Control Augmentation System						
Roll Damping						
VHF Radio						

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